AN ACCESSORY LENS FOR OBSERVING INTERFERENCE FIGURES OF SMALL MINERAL GRAINS

ALBERT JOHANNSEN
University of Chicago

As long ago as 1880 Bertrand[1] discovered that in the bubbles which are found so frequently in the Canada balsam between the mineral section and the cover-glass, there may be seen an interference figure of the mineral lying below it. The bubble acts as a lens of short focal length and takes the place of the objective, while the ocular and objective combined act as do the Bertrand lens and the ocular in the usual method of observing interference figures.

Later, Schroeder van der Kolk[2] carried this method a step farther. He placed a drop of glycerine upon the cover-glass of the slide to be examined and stirred it rapidly with a thin rod so that it became filled with small bubbles. Over this he placed a cover-glass and, between crossed nicols and with a medium-power objective, he depressed the tube a very little below the focal plane and found in each bubble a small interference figure. To avoid the necessity each time of preparing anew a glycerine foam, Schroeder van der Kolk used the following simple device: He placed a drop of Canada balsam on an object-glass and, if necessary, cooked it. After producing foam by rapid stirring, he placed a cover-glass upon it and the instrument was completed. To use it he placed it, cover-glass downward, upon the rock section and shoved it into such positions that bubbles appeared over the desired spots.

In using this method, the present writer found that he could not produce bubbles in well-cooked balsam. If undercooked, the gum would squeeze out at the sides and stick to the rock slice under examination and the bubbles would become distorted from their

[1] E. Bertrand, "De l'application du microscope à l'étude de la minéralogie," *Bull. soc. min. France*, III (1880), 93–96.

[2] J. L. C. Schroeder van der Kolk, "Ueber eine Methode zur Beobachtung der optischen Interferenzerscheinungen im convergenten polarisirten Lichte, insbesondere in Gesteinsschliffen," *Zeitschr. f. wiss. Mikroskop.*, VIII (1891), 459–61.

spherical form. Another objection is that the extra cover-glass increases the distance between the balsam film and the mineral and, as a consequence, a dark border surrounds each bubble and cuts down, materially, the size of the interference figure. If a piece of glass, full of minute bubbles and of the thickness of a cover-glass, could be prepared, it would be a great improvement. By removing the cover-glass of the rock section to be examined and pressing the new glass down over it on a drop of oil, the interference figures would appear sharp, of the full size of the bubbles, and without a dark border. Having no such glass the writer has prepared small lenses as follows:

A glass rod was heated over a Bunsen burner and was drawn out as thin as possible. Pieces of the glass threads thus obtained were again heated and again drawn out to hair-like thinness. These were broken into lengths of an inch and a half and the extremities held an instant in the edge of the flame, whereby truly spherical globules were produced at each end. After preparing a number of these spherical lenses, they were examined under the microscope and all that were not perfect or which contained bubbles were rejected. Likewise only those which had a diameter of less than $\frac{1}{125}$ of an inch (0.2 mm.) were retained. If, now, such a lens is placed directly in contact with the cover-glass over the mineral to be examined, and the microscope arranged with crossed nicols, ocular, and a medium- or low-power objective (No. 0 to 4, Fuess), there will appear in it a small but perfect interference figure. The microscope should be focused upon the glass sphere and the tube then slightly raised. A condensing lens is not necessary but without it part of the figure is cut off by the dark border. The optical character and dispersion can be determined as well by this method as by the use of a Bertrand lens, and the figure is decidedly sharper. By its means it is possible to examine the interference figures, undisturbed by surrounding minerals, of grains smaller than is possible by the Lasaulx, Klein, or Bertrand methods, and it possesses the further advantage that the mineral and the interference figure can be seen at the same time. By shifting the lens, the optical orientation of all of the grains in a section can be determined. When used in connection with the Fedorow universal

stage, interference figures may be obtained with low power objectives. This extends the usefulness of the Fedorow stage since it increases the rapidity with which determinations may be made in certain cases.

To permit the rapid examination of a slide the writer attaches a bit of soft modeling-wax to one side of the stage and in it places the glass thread at such an angle that the lens globule is in the center of the field and rests against the cover-glass of the mineral section. The latter may now be shifted around the stage as much as is desired, bringing, successively, the different mineral constituents under the lens, which remains undisturbed in the center of the field. Another method is to attach the rod of the lens to the rim of a cork ring, allowing it to project toward the center, and so tilted that it rests on the same plane as the bottom of the ring. This method better protects the delicate glass rod but is not quite so convenient, since both rock section and cork must be moved when it is desired to place different minerals in the center of the field.